

IN THE SENATE OF THE UNITED STATES.

LETTER

FROM

THE ACTING SECRETARY OF THE NAVY,

IN RESPONSE TO

Senate resolution of January 19, 1895, transmitting reports of the preliminary survey of Pearl Harbor, Hawaiian Islands.

JANUARY 24, 1895.—Referred to the Committee on Foreign Relations and ordered to be printed.

NAVY DEPARTMENT,
Washington, January 22, 1895.

SIR: In accordance with the provisions of the resolution of the Senate, dated January 19, 1895, I have the honor to transmit the reports of the preliminary survey of Pearl Harbor, Hawaiian Islands, commenced in April last, by the order of Rear-Admiral Irwin, the then commander in chief of the Pacific Station, and completed in July, at which time Rear-Admiral Walker was in command of the station.

A chart showing the result of this survey has never been published by this Department.

Very respectfully, your obedient servant,

W. MCADOO, *Acting Secretary.*

The VICE-PRESIDENT.

SAN FRANCISCO, CAL., May 10, 1894.

SIR: As I stated in a previous communication to the Department that I intended to ascertain the character of the bottom at Pearl Harbor Bar, I have the honor to submit a report containing the results of my examination of Pearl Harbor lochs and bar.

On March 12, 1894, accompanied by Lieut. C. A. Adams, U. S. N.; Lieut. W. M. Wood, U. S. N., and Mr. C. A. Brown, of Honolulu, I proceeded by train to the Peninsular Station, below Pearl City, and from the landing, a short distance away, we were ferried across to Fords Island, where we were met by the steam launch of the *Philadelphia*, which had been sent around for my use.

A thorough examination of the waters, shore line, and bar was made. The character of the bar, as ascertained by repeated soundings, con-

vinced me that it was nothing but coral sand. I therefore determined to fit out an expedition and demonstrate the correctness of my opinion by boring. Having secured everything needed we started April 2, as before, and commenced operations, the particulars of which are contained in the very interesting report of my flag lieutenant, C. A. Adams, to whom I intrusted the work, and who completed it in spite of the many difficulties he encountered.

In addition to the above work, a thorough examination of the shore lines was made and a site for a dry dock was selected in the west loch on the peninsular, to the northward of Fords Island. Four fathoms of water was found within 20 feet of the bank.

The position is perfectly sheltered, and is situated in a small cove suitable for the placement of a cofferdam. On this peninsular are two flowing wells of potable water, the wells being of the dimensions of 10 inches and $7\frac{1}{2}$ inches, respectively, which would insure an inexhaustible supply. The railroad passes the head of this peninsular, so that only a short spur or switch would be needed to reach the site of a navy-yard, and this, Mr. Dillingham, the president and general superintendent of the Oahu Railroad, has assured me would be readily done.

There are no wells nor present indications of fresh water on Fords Island. Its greatest elevation is 30 feet above the water. All material for a navy-yard would, of necessity, be ferried across from the present terminus of the railroad, on the eastern peninsular, a distance of nearly three-quarters of a mile.

While exploring and sounding around Fords Island much deeper water was found in many places than the soundings shown on the chart. This also obtained in the west loch of the peninsular.

I am very much indebted to Mr. C. A. Brown, the owner of the peninsular as well as Fords Island, for valuable assistance and kind hospitality.

I most respectfully submit to the Department that the acquirement of a naval station in the Hawaiian Islands is an absolute necessity, as it would give our Government the command of the Pacific. It would not profit much to have simply a coaling station. We should have a navy-yard, and the positions commanding the bar should be strongly fortified, and a perfect torpedo system completed.

I respectfully call the attention of the Department to the energy and ability shown by Lieutenant Adams.

I am also indebted to Lieut. W. M. Wood, United States Navy, for obtaining valuable information for me and for aiding me in establishing positions.

Before leaving Honolulu I took Rear-Admiral Walker all over the ground and gave him all desired information.

My observations were made entirely on my own responsibility, and involved no expense to the Government beyond the small amount of coal consumed by the steam launch.

I inclose the reports of Lieutenants Adams and Wood, and forward blue prints and specimens and copy of chart of Pearl Harbor, the original of which was left for Admiral Walker's use.

Very respectfully, your obedient servant,

JOHN IRWIN,

Rear-Admiral, United States Navy.

The SECRETARY OF THE NAVY,

Navy Department, Washington, D. C.

U. S. FLAGSHIP PHILADELPHIA,
Honolulu, Hawaiian Islands, April 12, 1894.

SIR: I have the honor to make the following report in regard to work done and information gained by me in reference to Pearl Harbor Bar, Oahu Island, Hawaiian Islands.

On Monday, April 2, with the steam launch and sailing launch of the U. S. Flagship *Philadelphia*, I attempted to set up sheer legs, or a tripod, on the bar for the purpose of boring to ascertain the nature of the material composing the bar. The legs of the tripod were 6 by 6 inch timber, 40 feet long, connected at the head with locked eyebolts. The depth of water was $1\frac{3}{4}$ fathoms. The facilities were not very good, and the wind and sea getting up from seaward, compelled the abandonment of the tripod, one leg being anchored. It was subsequently seen to capsize.

On Tuesday morning, April 3, the location of the tripod was visited at an early hour, when it was found that the legs had broken apart at the head, the bolt had been lost, and one leg had gone to sea. It then became necessary to transport the two remaining legs to Fords Island, and procure more material, which was done at once.

During the day a tripod was constructed of the same sized timber as before, with locked eyebolts at the head—the heads of each timber being sewed with marline to prevent splitting.

On each heel was bolted an iron pile point weighing about 50 pounds, above which was wrapped 15 fathoms of half-inch chain, securely nailed. The tripod was then so placed on the sailing launch that it might be raised with a tackle from her masthead.

On Wednesday morning, April 4, an early start was made. The tripod was successfully planted on the inner edge of the bar in 3 fathoms of water.

By 10.30 a. m., the boring apparatus was in position. This consisted of 2-inch case, or outside, pipe with 1-inch pump pipe and drill irons of the same size. In one hour 3 feet 3 inches of sand had been pumped out, the pump being an ordinary small "handy billy."

The pump, or suction pipe, was then removed and a chisel-faced drill put down, when a soft coral stratum was found growing somewhat harder for a brief interval. At 1.30 p. m. was obliged to discontinue work as the wind was rising, and sea coming in very heavily.

On Thursday, April 5, commenced work with the drill at 7.20 a. m., but was obliged to haul up the drill and put down the pump pipe as the case pipe was filling up and jamming the drill. The pump worked easily and the case pipe settled down from that time on until we were forced to discontinue work, at 12.30, on account of wind and sea.

The measurement of the pump pipe showed that a distance of 13 feet from the surface of the bottom had been reached, and the man directing the boring stated that, in his opinion, from 1 to 2 more feet of depth had been reached, and that, owing to the choking of the pipe, it was forced up before the measurement was taken.

Accompanying this report are specimens of the bottom at the surface; also of the borings at a depth of 7 feet and at 12 feet. The results are, first, about 3 feet of soft coral sand, evidently sifted on top of a light crush of dead coral, below which is again soft coral sand, easily yielding to the pump. In fact, the pump was apt to choke from the freedom with which the pipe went down.

It will be seen that a depth of 31 feet at low water can easily be obtained. In my opinion no blasting whatever would be necessary.

Had the boring and pumping apparatus, loaned by the department

of public works of the Hawaiian Government, been in good condition, and the man sent down in charge of it been younger—he was 70 years of age—and less timorous, much better results might have been obtained with the same labor.

I am indebted to Mr. W. E. Rowell, superintendent of public works, for many courtesies and valuable assistance, both at this time and subsequently, in obtaining data in regard to the Government dredge and the work at the mouth of Honolulu Harbor.

I have been able to obtain, through the courtesy of Prof. C. J. Lyons, in charge of the Government survey offices, blue prints of the soundings made on Pearl Harbor Bar by Lieut. J. C. Wilson, United States Navy, in 1887, and also those made under the direction of Lieut. Commander J. H. Sands, United States Navy, in 1873, which accompany this report. While these are undoubtedly on file at the Navy Department, they are not easily accessible for reference just at this time. Accompanying this, also, is a blue print showing the work done recently in clearing out the channel at the entrance to Honolulu Harbor, which was done by a dredge owned by the Hawaiian Government. A channel 200 feet wide and 1,100 feet long was dredged out to a depth of 30 feet at low water, involving the removal of 60,000 cubic yards of material. This included a depth of 8 feet below the shallowest portion. The time occupied was about six months, although there is no record of the actual working time. The cost of the labor was \$49,000, the contractor using the Government dredge, keeping it in repair and insured.

The dredge is a Von Schmidt patent, the makers guaranteeing the removal of 60,000 cubic yards of mud, in smooth water, in one month, or 10,000 cubic yards of coral sand. It is a steel screw and suction dredge, but in this case, on account of the swell on the bar, the screw could not be used, and only the suction with flexible rubber mouth was found to be available. The débris was discharged through 1,600 feet of 15-inch pipe, stationary, and from 200 feet to 900 feet of pipe on pontoons, varying with the position of the dredge on the bar. The dredge cost originally \$62,000.

In my opinion, from the experience in boring and sounding on Pearl Harbor Bar, a dredge of this description could clear a channel through the bar, giving a depth of 31 feet at low water without any great difficulty; and I am also of opinion that previous estimates of the cost of opening up this channel have been very much too great, owing to ignorance of the nature of the material forming the bar, and also of the powers of the modern dredge.

Owing to the sea breeze and heavy swell which sets in about the middle of the day on Pearl Harbor Bar the work might be retarded somewhat, but this could be compensated for by working a portion of the night.

Very respectfully,

CHARLES A. ADAMS,

Flag Lieutenant, United States Navy.

Rear Admiral JOHN IRWIN, U. S. N.,

Commanding United States Naval Forces, Pacific Station.

U. S. FLAGSHIP PHILADELPHIA,
Honolulu, Hawaiian Islands, April 11, 1894.

SIR: In obedience to your instructions, I conferred with the Government survey office here in regard to any data they might have concerning Pearl Harbor and the bar at its entrance.

At my request they have also located on our chart the line of the railway, as furnished them by the engineer of the railroad company, and indicated the well-established points on shore which we could use to angle on. They also permitted me to transfer to our chart the proposed cuts through the Pearl Harbor bar and channel. I was informed that no attempt had ever been made to determine the character of the bar, and that estimates as to the cost of cutting it had hitherto been made without definite knowledge of the formation of the bar.

Since the deepening of the Honolulu channel it has been assumed that the Pearl Harbor Bar is similar in character, as they are almost identical in appearance and condition.

The authorities offered everything they had that would aid us in our investigations, and have furnished the accompanying blue prints taken from the previous surveys made by the United States in 1873 and 1887. Excepting the above, they had nothing which would aid us.

In the positions located by us we found, as you are aware, the present soundings on the bar to agree with the chart, showing there has been no material change since the last survey.

Very respectfully,

W. M. WOOD,

Lieutenant and Navigator, United States Navy.

Rear-Admiral JOHN IRWIN, U. S. N.,

Commanding United States Naval Force, Pacific Station.

U. S. FLAGSHIP PHILADELPHIA,
Honolulu, Hawaiian Islands, June 21, 1894.

SIR: I had long been interested in Pearl Harbor and the facilities which it possessed for the establishment of a secure and commodious coaling and naval station, of great value to the United States, and while chief of Bureau of Navigation I had caused a survey of the harbor and its approaches to be made by officers of the U. S. S. *Vandalia*.

Upon taking command of this station, in April last, my attention was called to the new light which the development of the Honolulu bar had thrown upon the question of opening Pearl Harbor.

The entrance to Honolulu Harbor had recently been deepened from its original depth of 21 feet to a depth of 30 feet. This was easily accomplished, the material removed being coral sand, and the whole work was performed in a short space of time and at relatively small expense by a suction dredge, which pumped the sand from the bar and discharged it behind a retaining wall built upon the reef.

Prior to the examination of the Honolulu Bar by boring, it was supposed to be of coral rock. The Pearl River Bar was supposed to be of the same material, but if the latter, like the former, should prove to be nothing but sand, the difficulty and cost of cutting a channel would be much lessened.

Admiral Irwin had attempted an examination of Pearl River Bar before my arrival. He tried to obtain a boring on the bar itself, but failed, the tripod being overthrown by the heavy sea. He then obtained a boring on the western edge of the channel entirely inside the bar, and found nothing but sand. This boring is nearly 600 yards inside of the ridge of the bar and more than 300 yards inside of the 5-fathom line marking the inner limit, and at a point where no dredging would be required. This information has been supplied by Lieut. W. M. Wood, U. S. N., who accompanied Admiral Irwin to Pearl Har-

bor, and who platted the position. It will be embodied in the report hereinafter mentioned.

At the time of my taking command, therefore, the assumption that the Pearl Harbor Bar was composed of sand, although generally believed to be correct, was entirely unsubstantiated by any examination of the bar itself below its surface.

The *Philadelphia* was likely to remain here several months, and an opportunity was afforded of making a complete examination. The hydrographic survey of the harbor and its approaches having already been made, it only remained to determine the material composing the bar.

I therefore directed the commanding officer of the *Philadelphia* to organize a party and place it in charge of Lieut. W. M. Wood, the navigating officer, and to instruct him to make a thorough examination of the bar by boring at different stations to a depth of not less than 30 feet below low water. Lieutenant Wood began work on April 30 and finished yesterday. Every facility and assistance was furnished by the Government of Hawaii, which established and verified signal stations for his convenience, and by the Oahu Railway Company, which transported our men and material without charge. The surveying party occupied the house of Mr. C. A. Brown, on Fords Island, also without charge. The total expense to the United States Government of the survey, apart from coal and material supplied by this ship, has been less than \$50.

A full and detailed report with charts, plans, profiles, photographs, and estimates will be forwarded when prepared; but it will necessarily take some time to put the data into shape, and in the meantime I wish to inform the Department of the general result. The examination shows conclusively that there is a channel through the reef at Pearl Harbor filled with loose coral sand, and that a suction dredge can rapidly and cheaply open a way for the largest ships. Twenty-eight borings were made upon the bar, and a careful hydrographic survey of its immediate vicinity was also made. Of these borings, only three struck rock; and in each of these cases the position was near the edge of the live coral; and in each case by moving a few yards toward the axis of the channel an unimpeded boring was obtained. The borings varied in depth from 30 to 37 feet. The channel is practically straight and the distance between the walls of live coral is at no point less than 300 feet.

The work has been prosecuted under considerable difficulties. It was necessary to make the borings from a heavy tripod weighted to stand upright and to withstand the sea, and to move this tripod from station to station as the work progressed. The apparatus was improvised from the material at hand. The handling of the tripod was laborious, slow, and often dangerous, because of the heavy sea on the bar. The examination occupied fifty-one (51) days, and much credit is due Lieutenant Wood and his assistants for their persistent and successful industry in the face of obstacles and discouragements.

A further and detailed report will be made when the results of the examination shall have been put in shape for transmission. When received, the Department will have all the information requisite for dealing with the entire question—even to the point of preparing advertisements for bids if it should be decided to open the harbor.

I am, sir, very respectfully,

J. G. WALKER,

*Rear-Admiral, United States Navy,
Commanding United States Naval Force on Pacific Station.*

THE SECRETARY OF THE NAVY,
Navy Department, Washington, D. C.

U. S. FLAGSHIP PHILADELPHIA,
Honolulu, Hawaiian Islands, July 11, 1894.

SIR: I inclose a report of an examination of the bar at Pearl Harbor, Oahu, made by my order by a party of officers and men from the *Philadelphia*, under Lieut. W. M. Wood, United States Navy. The work occupied fifty-one days, was prosecuted under many disadvantages, with improvised instruments, was at times attended with danger, and has been well and thoroughly done. Lieutenant Wood and the officers and men of the party are deserving of much credit for their persistent and successful efforts.

The estimate of cost of opening a channel of 30 feet depth has been carefully made, but there are so many uncertainties arising from the chances of bad weather and consequent sea on the bar and in its neighborhood during the progress of the work, that a large margin should be allowed for delays, accidents impossible to foresee, and contingencies of all kinds.

The report is complete, and under separate covers I send five packages, lettered, respectively, A, B, C, D, E. Package A contains one hydrographic chart, showing the location of the work, one enlarged chart showing position of borings in channel across bar, one chart showing the contour of the bar, and two drawings showing the details of the apparatus employed; package B contains ten photographs; package C contains microscope slides; package D contains specimens of sand, and package E contains the copy of the field records.

I am, sir, very respectfully,

J. G. WALKER,
Rear-Admiral, United States Navy,
Commanding United States Naval Force on Pacific Station.

The SECRETARY OF THE NAVY,
Navy Department, Washington, D. C.

(Five accompanying packages under separate covers.)

U. S. FLAGSHIP PHILADELPHIA,
Honolulu, Hawaiian Islands, July 9, 1894.

SIR: In obedience to your order of April 23, I have the honor to submit the following report of the operations of the expedition under my command at Pearl Harbor and the results obtained in regard to the bar and the approaches thereto.

Before leaving Honolulu I conferred with the officials of the Hawaiian Government survey, and by them was offered every assistance and the use of any of their data which would aid in our work. I secured at this time a working sheet, showing only the shore line on each side of Pearl Harbor entrance. Prof. W. D. Alexander, the head of the survey office, also offered to detail some of his assistants to recover several of the primary stations used in the original topographical survey.

This was afterwards done by Messrs. F. S. Dodge and W. E. Wall, and their positions plotted on the chart referred to.

We afterwards constructed from this a working chart on a much larger scale, for use in the field.

Since our return Professor Alexander has kindly placed at our disposal a drawing room in the survey building and the necessary instruments (the ship not being provided with them) to enable us to prepare the accompanying charts.

I also secured from the management of the Oahu Railroad Company permission to use their road for the transportation of men and material, the latter including the daily rations of the party, and from Mr. C. A. Brown, the owner of Fords Island in Pearl Harbor, the use of two small buildings thereon, as quarters.

This location was the best available, being but $2\frac{1}{2}$ miles from the entrance and within easy reach of fresh water, none of which can be obtained lower down the harbor.

In this connection it may be well to call attention to the fact that there is an ample supply of excellent water on the Pearl City peninsula, directly opposite Fords Island, obtained from artesian wells, and there is also plenty of spring water to be obtained at the head of the east loch; a rice mill being operated there by water power furnished entirely by springs. It seems possible to obtain water in unlimited quantities any place in this region by sinking artesian wells.

Having completed the other necessary arrangements the expedition proceeded to Pearl Harbor and took up its quarters on Fords Island Monday, April 30.

The party consisted, besides myself, of Ensign S. M. Knepper, Naval Cadet F. B. Upham, Passed Asst. Surg. R. P. Crandall, and 11 enlisted men, one of whom was a wardroom servant, who acted as cook for the entire party. Dr. Crandall alternated week and week about with Asst. Surg. M. S. Guest.

A week later a carpenter's mate was added to the party.

On leaving Honolulu on the 30th of April we were accompanied by Messrs. Dodge and Wall. These gentlemen were landed that same day at Puuloa, on the west side of the entrance, and picked up again the following afternoon. During this time they occupied two of the old stations, and located three new ones for our use. These stations were permanently marked at this time by concrete blocks sunk in the ground, and having crosses on their upper faces. We subsequently placed flags on poles over these marks for use in our observations.

In addition to the regular party from the ship, I also secured a native pilot and a diver. Their services were of great assistance in our early work, but were dispensed with as soon as we became familiar with the working ground and it was discovered that two of the enlisted men of the party were excellent divers and able to do all that had been hitherto done by the natives.

The equipment of the expedition consisted of a steam launch and the second dingey from the *Philadelphia*. We found at Fords Island a flat-bottomed skiff belonging to Mr. Brown which was invaluable for our work, and was so used in place of the small dingey, which took its place at the island as a ferryboat. The Interior Department of the Hawaiian Government loaned a decked scow 35 feet long, 15 feet wide, and 6 feet deep, and having a draft of about 18 inches; also a small and not very efficient hand force pump (which they put in as good order as possible before it was turned over to us) and a lot of old piping and drills, all of which had been used some three years ago in exploiting the Honolulu Channel before work was commenced there. The pump, when overhauled, was fitted with a new rubber discharge hose, and latter, at my request, with a flexible rubber suction hose to replace the rigid one of pipe originally furnished and which was found extremely difficult to handle in the rough water on the bar.

The scow was furnished with a geared winch at one end, and at the other we erected an overhanging derrick made of two pieces of scantling 6 by 4 inches by 25 feet long. As thus equipped, with proper moor-

ings and towlines, she became our working base for the "boring" operations.

In addition to the above we were furnished from the ship with several tackles, three boat anchors, and a 400-pound kedge, together with lines for anchors and towlines. A quantity of small stuff and marline for lashings was also provided.

Three small keg buoys fitted with grate-bar moorings completed the original outfit. The men carried with them their mess gear, bags, and hammocks.

The buoys above mentioned were supplemented by 25 wooden buoys made on the working ground, with old chain borrowed for the purpose for anchors.

These small buoys were distinguished by the letters of the alphabet and used to mark the place of each boring as it was made and thus insure the work being properly distributed. Two of the keg buoys were placed before anything else was done, in 30 feet of water, one inside and the other outside the bar, thus marking approximately the limit of our operations.

The one on the inside remained in position during our stay and was left there, the other soon sank or was carried away by the sea. The third of these buoys was used at first to mark the shoalest water on the ridge of the bar, and afterwards was of much service as a marking buoy. It was left on one of the coral bowlders referred to later in this report.

In addition to the stations established by Messrs. Dodge and Wall, we built and located two additional stations on the eastern reef. These were wooden tripods carrying flags, and were held in position by lengths of old chain. One was swept away several times by the sea before being finally secured. Their positions were established from the primary stations by sextant angles.

Almost immediately after our arrival an unusually heavy swell from the southward set in, at times breaking clear across the bar. It lasted for the best part of a week, and was undoubtedly due to a blow that was not felt here. It was unusual at this season, and nothing like it had been seen for more than a year.

During the time of our stay at Pearl Harbor there was no absolutely smooth water on the bar, though on three occasions there was so little swell as to cause no inconvenience. It was on one of these days, May 24, that the accompanying photographs were taken, the tripod being at position L in 11 feet of water.

It appears that the prevailing local swell setting across this bar is caused entirely by the northeast trade wind and is more or less heavy, according the strength of the trades. It approaches the bar well from the southward, evidently being materially changed in direction as it sweeps around the eastern end of Oahu. Hence on the bar the wind which causes the swell crosses the latter nearly, if not quite, at right angles to its direction. This almost constant wind causes a current, especially on the flood tide, to set across the bar to the westward.

This is a most important point, taken in connection with the formation of the eastern reef, in the event of operations to cut a channel through the bar.

It was also noticed that on all occasions the swell was heavier at extreme low tide, smoothing down almost immediately after the water began to deepen. This would indicate that as the dredging proceeds the swell would give less and less trouble.

When the trade wind fails and light breezes set in from the southward, the sea subsides and remains so until the trades freshen again, the southerly swell referred to above being the exception.

I have called particular attention to these facts, as the state of the sea will be the main question in the dredging operations, and a heavy swell is the only thing likely to hinder work.

During the many years Pearl Harbor has been considered as a naval station and harbor, it has never until now been demonstrated what were the physical characteristics of the bar which blocks its entrance. Indeed, until the operations at Honolulu in 1892, the general belief has always been that at both places the bar was a solid coral reef requiring expensive blasting operations to remove.

This belief was confirmed at Pearl Harbor by previous investigators, who probed the surface of the bar with iron or steel rods. They either did this outside the limits of the sand area, or the resistance offered after penetrating the sand two or three feet was so great that they supposed they had struck solid rock. It was not until recently that an attempt was made to use the pumping process by a party (of which the writer was one) under Rear-Admiral John Irwin, U. S. N. This party had throughout the assistance of an expert "well borer," Captain Robertson, and at the first attempt the advice and aid of Mr. Rowell, superintendent of public works. At this time a tripod to operate from was successfully placed on the bar proper, but, owing to defects in its construction, it was immediately wrecked by the seas. In a second attempt, two days later, the bar itself was not reached, but, owing to an error, the tripod was placed on an inner shoal. Here a pipe was sunk to a depth of 13 feet in 15 feet of water. This position is marked as position A on the accompanying charts.

Before proceeding to our operations on the bar I will give a brief description of the apparatus used and the method of "boring" or, more properly, "sinking" a hole. In the accompanying sketch No. 1 A is a 1-inch hose, and it is the discharge pipe of the small hand force pump mentioned above. At the upper end this hose is connected by an ordinary hose coupling to B, a 1-inch iron pipe. This pipe is somewhat longer than the outer or casing pipe C, and is prevented from slipping through the latter by an ordinary lathe dog, clamped on to it at E. This allows the inner pipe to project slightly beyond the outer, as shown in the sketch. The 1-inch pipe has two deep notches in the lower end to allow free egress of water when resting on the bottom. The outer pipe C is made of ordinary galvanized pipe 2 inches in diameter and 36 feet in length.

Twenty-one feet from the lower end a T is placed to make a free opening at D for the discharge. Both these pipes are made up of short lengths joined by ordinary couplings, care being taken, however, that the lower length of C, from the T down should be in one unbroken length to prevent the resistance a coupling would cause in entering the sand. This distance was fixed at 21 feet as the maximum depth required in the sand to insure a depth of 30 feet at mean low water at the shoalest point on the bar. At the conclusion of our work, in an attempt to sink a deeper hole, it was discovered that the little pump was not strong enough to work against a much greater head than this. There is every reason to believe that the sand is of much greater depth than the 21 feet reached by us on the ridge of the bar, as it will be noticed that at many of the positions in deeper water the pipe was sunk the full 21 feet below the bottom.

The apparatus as thus arranged was the result of considerable experi-

menting and many changes, but as finally fitted was found to work most efficiently.

In operation these pipes were placed vertically with the lower ends resting on the bottom. While in this position the hose was connected as seen in the photograph marked A. After this the pipe was plumbed by the eye, and the oar, which can also be seen in the photograph, removed. This oar was used as a "fish" to strengthen the pipe and prevent bending or breaking at the joints while handling it in the seaway. Several such accidents occurred in the early part of our work. Being finally plumbed in position and free of all gear, the pump was started and a stream of water forced through the inner pipe. By following the course of the arrows in the sketch it will be seen that this stream impinged against the bottom, cutting the sand away and carrying that loosened upward in the annular space between the pipe until it escaped through the opening at D. Of course as the sand was cut away the pipes slowly sank, the operation being aided by an occasional twisting or boring motion given the outer pipe. This was done in the early part of the operation by hand, but as the pipes sank deeper and the frictional resistance became great a couple of "stilson" wrenches were used.

After the required depth was reached the hose was disconnected and the pipes were drawn by a tackle hooked well under water by a diver.

In the deep, smooth water of the Honolulu channel and with a maximum boring of only 12 feet it was found possible to effect the operation by pumping from the deck of the scow moored securely for this purpose. It was suggested we might succeed equally well at Pearl Harbor, and on the strength of this advice our first attempt was so made.

It was on the next day after our arrival and before the heavy southerly swell referred to had set in. It soon became evident that with the scow as our working platform, rolling, pitching, and veering, it would be impossible to accomplish anything in this way. Later, when working in deep and smooth water where the depth was too great for the tripod and the borings required only 5 or 6 feet in depth, we succeeded in making borings thus. I have since learned that in Honolulu, where this method was used, they had the assistance of a man in diving armor to steady the pipe on the bottom independently of the scow.

Having determined that the method was certainly impracticable under the conditions ordinarily existing on the bar at Pearl Harbor, it was decided to construct a "tripod" which would afford a stable support to work from. At the end of the first day's work, and to avoid the heavy tow, the scow was left at anchor on the inner slope of the bar, where it was thought the "tripod" could be put together and erected. On our arrival the next morning with the necessary materials, we found the heavy swell had set in during the night, and that the derrick we had erected on the scow had been rolled out of her, fortunately hanging over the side by its guys. We were therefore obliged to tow the timbers back and land them near the entrance at Puuloa. The launch then returned to the bar, and with some difficulty succeeded in getting hold of the scow, slipping and buoying the cable and towing it into smooth water. At this time the sea was breaking close up to her. The balance of the day was devoted to work on the "tripod" at Puuloa.

On the 14th of May this "tripod" was hoisted for towing, and successfully landed in the shoal water on the bar. It proved, however, to have too little spread to the legs and to be insufficiently weighted, and was immediately capsized by the heavy sea still running. After several unsuccessful attempts to right it and give the legs more spread we were obliged to tow it back to Puuloa with a view to reconstructing it.

The second "tripod," in which more weight was added to the legs and their spread increased, was finished by the morning of the 5th, and it was again taken out to the bar and placed in position at the desired spot.

Unfortunately, at the moment of landing it, a line fouled the propeller of the steam launch, notwithstanding a man was especially stationed to guard against such an accident, and the scow was immediately driven back by the sea onto the "tripod," demolishing it. This happened late on Saturday. On Sunday morning the scow and wreck were towed back to Puuloa, and by the earliest train on Monday, May 7, we received the material necessary to rebuild the "tripod." By the afternoon of the 8th it was finished and in place for work at position B. (See Charts A and B.) From now on the work was prosecuted, not without trouble, but without serious delays or accidents.

This third "tripod" was successful in every way, and is the one seen in the photographs submitted.

It is also shown in the accompanying sketch No. 2, where all its principal dimensions are given. On many occasions during our work the sea broke through our "tripod", as high as the middle working platform without disturbing its stability or causing more inconvenience than the difficulty experienced in boarding and leaving it with the piping and pumping outfit. It was always placed so the two front legs would face the prevailing swell, the third leg having the most spread, and thus giving it greater stability. In photograph A the pump is seen located on the middle platform, but owing to the excessive "lift" was afterwards transferred to the lower one, as seen in photograph B. In B the boring is seen to be well under way, the pipe having sunk about 16 feet into the sand.

The position of the highest platform is only shown by a single horizontal strip of wood. The rest of it was secured by lashings, and removed when working in shoal water.

As seen in sketch No. 2, all the woodwork of the tripod is bolted together with heavy through bolts, and then the structure further strengthened at the principal angles by strong lashings. A heavy rope "span" for lifting the tripod can be seen in the sketch, and as in use in photograph C. The line secured at the apex was used successively, first, as a guy rope to steady the head when hoisted for towing, as in photograph C; next, for anchoring the tripod after planting, and thus to secure it in case it was overturned in our absence, and lastly, as a towline when moving it into smooth water in order to change its position, as hereafter described. The method of handling the tripod was as follows:

The scow was first anchored in smooth water, not less than 25 feet in depth. The tripod was next floated under its stern and slewed into proper position for hoisting, the head guy being carried forward and belayed and the main tackle being hooked (one of the men diving down with the lower block to do so), its fall was taken to the winch and the whole structure hoisted as high as possible, veering the head guy as necessary.

It is seen in this position in Photograph C. To prevent the legs from straddling the scow, a 6 by 6 inch timber 24 feet long was permanently lashed across the stern. The front legs rested against this timber and the two wedge blocks, placed, one on each leg, under the eyes of the slings prevented anything from catching as the "tripod" was lowered. Cross guys were also used, one on each of these front legs, to prevent shifting when the scow rolled and pitched. These were come

up just before lowering. When hoisted as high as possible the legs were still some six or seven feet in the water, and even then would often touch in the trough of the sea when crossing the shallow water on the ridge of the bar.

With the "tripod" thus lifted and secured the scow was taken in tow by the launch and moved out to a position selected and previously buoyed. This towing taxed our steam launch to the utmost, and at times, when the wind was fresh, we were obliged to aid her by kedging.

The view in the Photograph C is at the moment of "letting go." The cross guys have been come up and thrown over the forward lower brace of the "tripod." One man is on the "tripod" to go with it and unhook as soon as the tackle slackens on the "tripod" striking the bottom. Two others on the front end of the scow are tending the fall of the main tackle and the head guy, with everything clear for running. A fourth man stands at the foot of the derrick ready to bend an anchor line to the head guy before it pays overboard, and thus convert it into a mooring line. At the order everything is let go, the launch continuing to tow straight ahead to avoid the danger of the scow being set back onto the "tripod." Usually the man on the "tripod" was able to unhook the tackle, and by it swing himself on board the scow before it got out of reach. Several times, however, we could not unhook at all, and were obliged to let the tackle unreeve. When the launch towed far enough ahead to tauten the mooring line, the anchor was let go and the "tripod" left in position for the next boring.

It was usually found best to devote the latter part of the day to moving the "tripod" and thus leave it in position for work on the following day. The scow was always, after our first experience, taken into a sheltered position and anchored for the night. On resuming work in the morning the scow was towed out into a good position to windward of the "tripod," and there anchored, with a very long scope, veering as near the "tripod" as the conditions of the weather would permit. Photograph D shows their relative positions on that day. The next operation was to place the planks forming the working platform and then to transfer the piping, pump, and tools. In smooth weather this could be done directly from the deck of the scow, using the tackle from the "tripod" and suitable guys. In heavy weather the pump was lightered over in the flat-bottomed boat, and the piping, buoyed with barrels fitted for the purpose, floated near enough to the "tripod" to hook the tackle to it and upsend it. Under ordinary circumstances it was impossible to pick the "tripod" up again on the bar without seriously endangering the whole structure, for before it could be lifted clear of the bottom by the derrick the scow would be driven down upon it with the full force of the sea.

Hence, after the boring was finished and apparatus transferred back to the scow, the latter was hauled ahead some distance from the "tripod," but still with good scope on the cable. Three barrels properly slung and fitted with long rope lanyards were then floated alongside the "tripod" and the "lanyards" rove through thimbles secured to each leg beneath the surface of the water. This, was of course, done by divers. The "lanyards" were then hauled as taut as possible, and hitched high up on the structure. This all being done, the head guy, which had been previously carried on board the scow after weighing the anchor attached to it, was hauled in and securely belayed; the cable was then brought to the winch, and by heaving the scow ahead the "tripod" was toppled over. The barrels thus acted as floats to bear up at least a portion of the weight on the lower ends of the legs. Even

then these legs dragged more or less heavily on the bottom until the water deepened. Without them it was next to impossible for the launch to move the "tripod." As soon as it was capsized the guy line was given to the launch, and by it the "tripod" was moved into the deep and smooth water inside the bar. It then floated in a vertical position. As the launch could not manage the capsized "tripod" and scow together, she was obliged to anchor the former and make a second trip out for the scow. After the scow was brought in and anchored the "tripod" was again brought alongside as already described.

It will be readily understood that handling this "tripod" in a seaway on the shoal water of a bar was attended with considerable risk to those employed, and required both courage and skill. G. F. Seabrook (seaman) and R. P. Whitney (apprentice, second class) were particularly efficient in all these operations. Seabrook was always lowered on the "tripod," until, on June 8, near the conclusion of our work, he unfortunately broke one of his fingers in getting from the "tripod" into the skiff. After this Whitney took his place. There was also much work done under water, and these two men did all of it after the discharge of the natives.

Photograph F was taken to show the peculiarly steep beach and deep water at Puuloa, just inside the entrance on the west side of Pearl Harbor.

This beach is of coral sand and the launch in the picture has her bow hard aground on it, the tide being low. The lead at the stern shows $3\frac{1}{2}$ fathoms, while another boat length farther out there is fully 6 fathoms. In other words, the largest of vessels could almost be moored broadside against this beach. Deep water close to the shore is a characteristic of the greater portion of Pearl Harbor, but this is the only extensive sand beach. In the remainder of the harbor the general characteristics of the shore are such as seen in photograph G. This was taken at the landing at Fords Island and includes the working party. It is also low tide at this point; the ledge on which the officers are standing being covered by some 2 feet of water at high tide. The ledge is perpendicular, or even overhanging, with 4 to 5 feet of water alongside it and deepening rapidly to 6 or 7 fathoms. It is fully 6 fathoms deep 50 feet outside the launch, and such is the case for miles in all three "lochs."

Photograph H shows Puuloa beach a little farther south, and in the middle distance can be seen an ancient stone fish trap placed on a shoal point making well out to the deep water of the channel. This trap is only exposed at half tide, and is marked on the hydrographic chart (No. 1141) of Pearl Harbor. This trap is similar in principle to the stake nets used so commonly on our coasts. The native legends do not go back far enough to tell when it was built.

On the hydrographic chart of Pearl Harbor accompanying this report will be found the line of the Oahu Railroad, where it touches Pearl Harbor; also several coral bowlders located by us and dangerous to small vessels. These bowlders have respectively 5 feet and 6 feet over them at low water, and were left temporarily buoyed, as before mentioned. They are surrounded by 14 feet of water; this deep water extending well to the westward, while the main channel is quite close to the east. The rectangle in red on the hydrographic chart shows the scope of our work as shown on A and B. The accompanying photographs I and K, taken from paintings, give a good idea of Pearl Harbor and the surrounding country.

In locating the accompanying positions it was found that owing to

the configuration of the land, the signals fell so near on the periphery of a circle passing through the bar that the ordinary three-point problem would be inaccurate. Hence all the tripod positions and most of those used to locate the live coral were obtained by angles observed from the stations on shore.

From May 9, when the first successful boring was made, the work progressed, with only slight interruptions from the weather, until the last was sunk on June 15.

The party returned to the ship on the morning of June 20, the intervening days between the 15th and 20th being devoted to necessary hydrographic work.

The following is a summary of the results obtained at each position:

Date.	Position.	Mean low water.	Depth pipe was sunk into sand.	Remarks.
		<i>Feet.</i>	<i>Feet.</i>	
May 9	B	11	21	Another boring was made here to 17 feet; the pipe was then lengthened.
May 14	C	12	13	Struck coral. Three attempts to go deeper were made.
May 15	D	9	21	
May 16	E	11	21	
May 17	F	14	21	
May 18	G	14	21	Lumps of dead coral seen on sand near this position; some of them were brought up by divers.
May 21	H	14	21	
May 22	I	15	21	
May 23	K	19	16	
May 24	L	11	21	
May 25	M	15	20	
May 28	N	21	13	
May 29	O	8	21	The full depth could not be reached here on account of limit of apparatus.
May 30	A'	24	10	
May 31	P	16	17	
May 31	B'	21	13	
May 31	C'	23	11	
June 1	Q	10	21	
June 4	D'	27	7	
June 6	R	14	21	Live coral.
June 8	S	18	0	
June 8	T	18	16	Do.
June 9	U	19	0	
June 9	V	21	12	
June 9	F'	22	11	
June 9	E'	26	7	
June 12	G'	26	7	
June 13	W	14	0	
June 15	X	19	15	It was here an attempt was made to lengthen the pipe and make a maximum boring. It could not be done with our apparatus.

NOTE.—All the positions marked ' were made from the scow.

Specimens of the bottom at varying depths were obtained from enough of the borings to give the character of the sand. They were obtained from the discharge opening of the pipe by divers, in many cases from the full depth of 21 feet. Passed Asst. Surg. R. P. Crandall has made a microscopic examination of this sand and finds it is composed of minute fragments of coral rock rounded and smooth from attrition, small pieces of broken lava, fine sand, and minute shells or Foraminifera. The different specimens do not differ materially.

The accompanying microscopic slides prepared by Dr. Crandall are submitted, together with a small bottle of the sand obtained at each position and appropriately labeled.

In the dredging of Honolulu Channel it was soon found that the dredger could not be used in a sea way in the same way it was designed to operate in smooth water. Under ordinary conditions the dredger is

secured in position by a pile driven into the bottom, and called a "spud." With this as a fixed center, it swings around, operating, if necessary, on the full circle described. This method had to be abandoned when working in open water, as the motion soon broke the "spud" short off. Anchor moorings were then resorted to and no further difficulty was experienced from this cause, though the rapidity and scope of the work was somewhat reduced. It is even thought that perhaps in the shoaler water on Pearl Harbor bar the "spud" might be used, as the leverage would be so much less. I however believe anchor moorings will be the only sure method. Everyone familiar with the subject agrees that, so moored, there will be no difficulty in operating the dredger off Pearl Harbor, although the bar lies a full mile from the land. At Honolulu the work was done in and near the entrance to the harbor.

In some respects, as will be shown later, this outlying position offers advantages that will tend to cheapen the cost of the work as compared with Honolulu. At the latter place an expenditure of \$62,500 was made for a retaining basin and pipe pier thereto, both of which will be unnecessary at Pearl Harbor.

In addition to the breaking of the "spud," it was soon found to be impossible, on account of the motion, to use the rigid arm carrying the suction pipe to the bottom.

On this account a material modification was made in this part of the apparatus to fit it for work in rough weather. To do this the outer end of the regular suction pipe carried by the "ladder" or arm was closed by a "blank." Just inside of the outer end, and on the under side of the suction pipe, a new opening was cut. Here a casting was bolted to which a flexible rubber tube could be fastened. This rubber tube was 7 feet long and 15 inches in diameter, the same as the metal suction pipe. A number of iron hoops 4 inches wide were fastened quite close together inside this tube to prevent it from collapsing in use. At the other end this flexible tube was secured to a length of ordinary sheet-iron piping of the same diameter and 12 feet long, the lower end of this in turn being riveted to a cast-iron flanged "elbow." To this flange was bolted a peculiar cast-iron mouthpiece.

Inasmuch as this modification was found efficient in practice, and as it can be applied to any form of suction dredger engaged in similar work, I submit the accompanying working drawing No. 3. This sketch shows fully its construction. The mouth was made long and narrow and provided with a bridge cast across it to prevent large lumps, which would be liable to jam in the pump or discharge pipe from entering. This new suction pipe was raised, lowered, and moved about by moving the "ladder" as before. In addition to its connection to the old suction pipe as described, it was provided with a rope guy from a "lug" cast for the purpose on the lower "elbow." The sharp points or "feet" served to keep the mouth from hugging too close to the bottom, and it was also thought that in moving the pipe about they would tend to cut up the sand. It is doubtful whether they were of much use in this way, however. This pipe worked efficiently in rough weather, its flexible section remedying the difficulties experienced with a rigid pipe. The lower end of the regular suction pipe, as used in smooth water, opens through the center of a revolving cutter. When this pipe can be used these knives add materially to the efficiency of the dredger by cutting up the sand. They will even cut and break up soft coral rock.

This machine is the property of the Hawaiian Government, and would undoubtedly be loaned for opening a channel at Pearl Harbor.

It is a suction dredger of the Von Schmidt pattern, and cost, including 3,000 feet of pipe, with pontoons to float 1,000 feet of it, \$65,000. An additional \$9,000 was spent to complete the outfit, thus bringing the total up to \$74,000.

The principal dimensions of this dredger are as follows: Hull, 40 feet by 100 feet, by 9 feet deep, and it draws about 4 feet of water. It is fitted with a main centrifugal pump, having a "runner" $4\frac{1}{2}$ feet in diameter, and driven by a pair of compound condensing engines of 350 horsepower. For driving the cutter gear described above, there is a pair of 75-horsepower engines, while another pair of the same size operates the winding gear, etc. Steam is supplied from two fire-box boilers 6 feet in diameter and 22 feet long. All the engines and pumps exhaust into a surface condenser. This dredger was built by the Risdon Iron Works, of San Francisco, Cal., who were also the contractors for the work at Honolulu.

The original guaranteed capacity of the dredger was given by the builders at 60,000 cubic yards of material per month in smooth water, or 10,000 cubic yards of coral sand in the ocean water. Mr. W. E. Rowell, the present superintendent of public works at Honolulu, who has since operated this dredger a good deal, considers the first of these estimates too large, and the second not large enough. He believes that now, since the modifications were made and experience gained in operating under the circumstances encountered here, the dredger should handle at least 20,000 cubic yards per month.

All these estimates are based on working continually night and day.

In deepening the channel at Honolulu 60,000 cubic yards were removed. It was done in six months, from June to December, 1892, during which there were many delays, including the time required to make the alterations in the dredger outfit as described.

In addition, the delivery pipe was at this time 2,600 feet long and the pumping done against a head of 7 feet.

In the accompanying estimates I have assumed that under the conditions at Pearl Harbor this dredger should be able to handle 15,000 cubic yards per month. This leaves a large margin on what it is considered capable of.

The cost of the contract work at Honolulu will be referred to later in comparison with the estimates for Pearl Harbor.

Having given in a general way the description of the methods and appliances used in similar work at Honolulu, together with as full an account as possible of our researches at Pearl Harbor, I will now proceed to a comparison between the two places, with estimates of the cost of cutting a channel through Pearl Harbor Bar, based on the accompanying data:

First. Our borings, which fully cover the bar and its approaches, show conclusively that nothing but loose sand is to be met on the line of the proposed cut to a depth of at least 30 feet at mean low water.

Second. That though this sand is bordered on each side by a live coral reef, the one to the westward has deeper water over it than the sand. Furthermore, that this deep water extends a long distance to the westward even inside the breakers, and that, due probably to the prevailing winds, there is a current in that direction.

Third. That at Honolulu an important part of the problem was to dispose of the sand removed so as it would not wash back into the cut, and this was only done by building a retaining wall at great cost, and adding much to the operating expenses of the dredger, due to increased head and friction in piping.

Fourth. That, owing to the conditions existing at the Pearl Harbor Bar, the sand could be discharged with perfect safety over the reef to the westward and through a floating pipe of comparatively short length. This would reduce the head to nothing, and the friction in the pipes to a minimum. Furthermore, with the dredger working from the inside out, this floating pipe could be tailed on behind it, and thus secure a lee where it joins the dredger. From thence it could be gradually curved to the westward over the reef. This piping is in 30-foot lengths, each floated by its own pontoon, and joined together by rubber couplings. Hence it can be given any direction and varied in length as desired.

The contract price for deepening the channel at Honolulu was \$49,000. In the progress of the work 60,000 cubic yards of coral sand was removed, the cost per cubic yard being therefore 81 $\frac{2}{3}$ cents.

As already stated, it took about six months, including delays from the weather, altering the suction pump, etc. The width of the dredged channel at Honolulu is 200 feet without allowance for slope. The running expenses of the dredger, making a liberal allowance on all items, are as follows. These expenses are for a continuous run with two shifts of men. The coal used cost but \$6.65. The coal furnished the *Philadelphia* runs from \$7.65 to \$8.35 without lighterage. These prices are presumably for a better coal than that used by the dredger:

Running expenses of dredger per twenty-four hours.

Coal, 11 $\frac{1}{2}$ tons, at \$7.65	\$87.97
Labor, two shifts	80.00
Oil, waste, and repairs	15.00
Towing and incidentals	17.03
Total	200.00
Or per month	6,000.00

No allowance is made for expert supervision nor for insurance on the dredger.

If the dredger will handle 15,000 cubic yards per month, and the expenses are \$6,000, it will cost but 40 cents per cubic yard.

To allow a perfectly safe margin and cover unforeseen delays and expenses, let the cost be fixed at 50 cents per cubic yard.

If the proposed cut in the bar proper be 250 feet wide, which is as wide as can be made without touching the coral, and to a depth of 30 feet at mean low water, it will necessitate the dredging of 200,000 cubic yards, and will cost \$100,000.

If the channel be 200 feet wide the number of cubic yards will be 160,000, and the cost \$80,000.

It will take thirteen and one-half months of uninterrupted work to accomplish the first, and ten and two-thirds months the latter.

However, fifteen and twelve months respectively should be allowed to cover delays and other causes. At one point inside the bar, where borings were made at A', B', C', it will be necessary to widen the channel.

Here the bottom is very soft, and being well protected from the swell by the reef, the dredger could be used as fitted for smooth water and its capacity run up to say 40,000 cubic yards per month. It would cost then but 15 cents per cubic yard to remove the sand. It would be necessary to remove 30,000 cubic yards, which would cost \$5,000, and require about twenty-five days, which allows five days for delays, at \$100 per day.

To make cut 250 feet wide through bar, with a depth of 30 feet at mean low water	\$100, 000
To widen and deepen channel inside to 30 feet at mean low water.....	5, 000
Total	105, 000
If cut in bar is made 200 feet wide the cost will be	80, 000
Inside channel	5, 000
Total	85, 000

In this connection attention is called to the fact that the "Kona" or stormy season is from November to February, inclusive, although it does not necessarily follow that any really heavy storms will be experienced.

The heaviest trade winds blow in July and August, while May and June are said to be the quietest months of the year.

The accompanying charts A and B were prepared by Ensign Knepper, and the drawings were made by Private H. Orrock, United States Marine Corps, from my rough sketches. The ink work of the charts was also done by Private Orrock.

In conclusion, I beg to state that both officers and men gave cheerfully their full energies to obtain the above results. Naval Cadet Upham showed marked officer-like qualities while on this detached service.

Respectfully,

W. M. WOOD,
Lieutenant, United States Navy.

Capt. A. S. BARKER, U. S. N.,
Commanding.

(Eighteen exhibits accompanying, consisting of one Hydrographic Office chart, two enlarged charts showing positions of borings, two drawings, 10 photographs, one box microscope slides, one box specimens of sand, and copy of field record.)

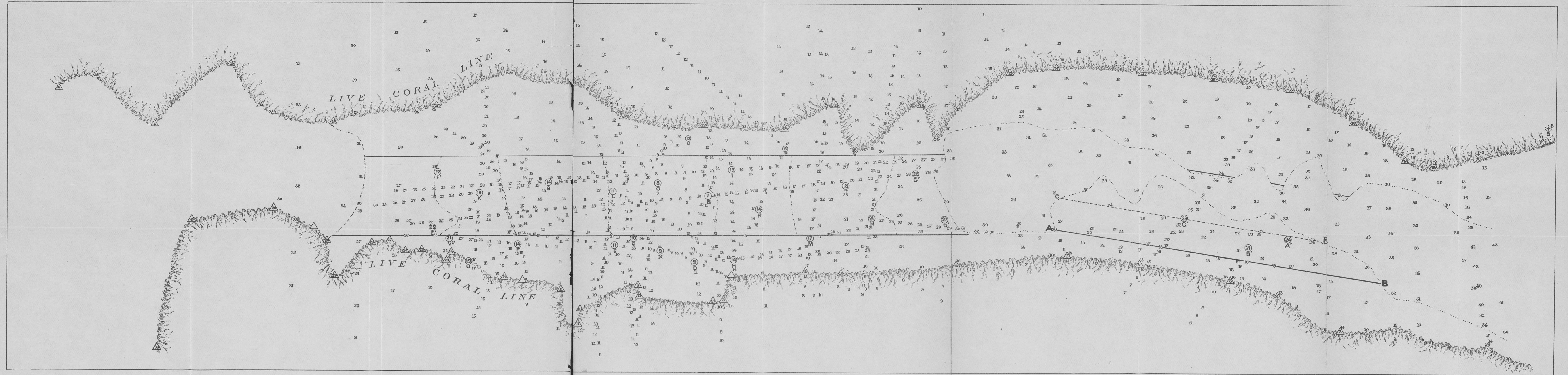
NAVY DEPARTMENT,
Washington, January 28, 1895.

SIR: Referring to the Department's letter of the 22d instant, transmitting, in accordance with the provisions of the resolution of the Senate dated January 19, 1895, the reports of the preliminary survey of Pearl Harbor, Hawaiian Islands, I have the honor to transmit herewith, under separate cover, a tracing of the chart showing the result of this survey, which was referred to in the second paragraph of the above-mentioned letter.

Very respectfully, your obedient servant,

H. A. HERBERT, *Secretary.*

The VICE-PRESIDENT.



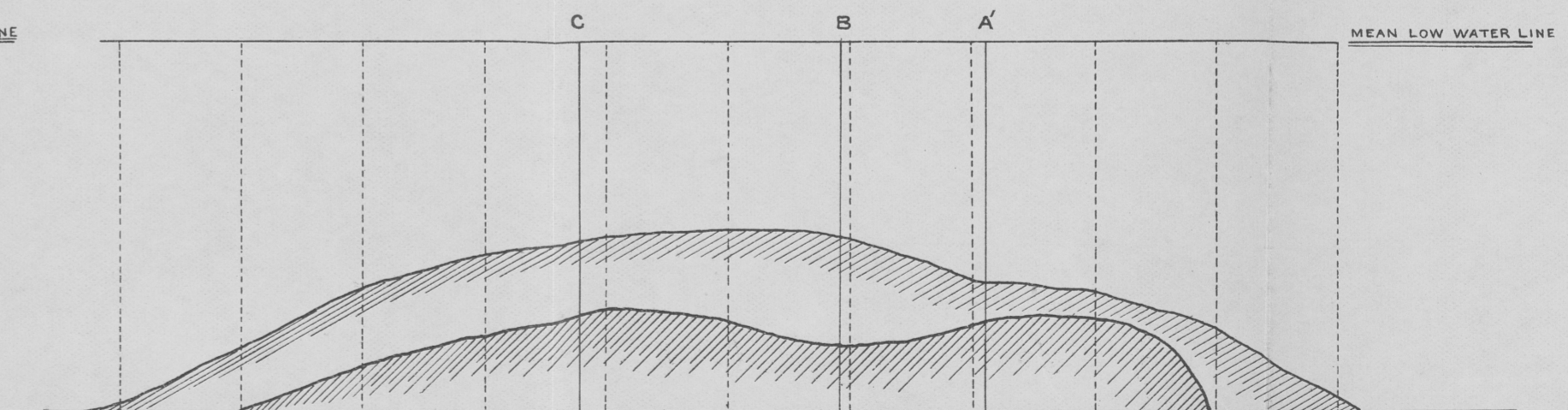
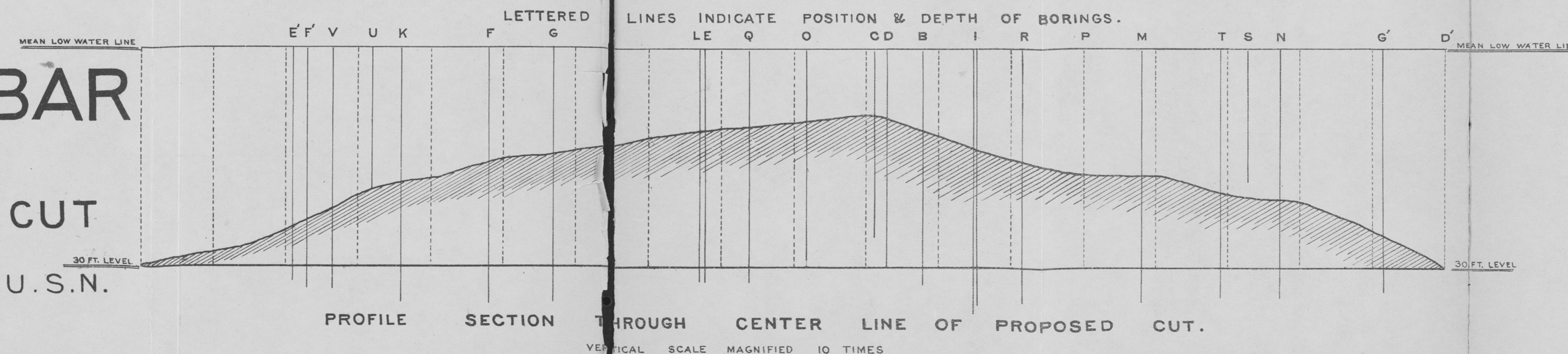
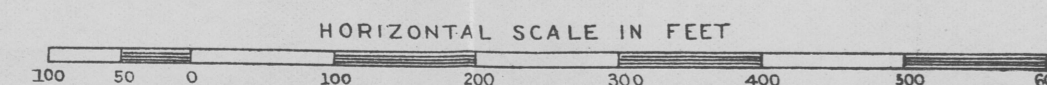
PEARL HARBOR BAR

CHART B

SHOWING PROPOSED CUT

REPORT OF LIEUT W.M.WOOD. U.S.N.

SOUNDINGS IN FEET.



S Ex 42 53 8